Water Delivery and Giant Planet Orbital Limits for Habitable Planet Formation

Sean Raymond (raymond at lasp.colorado.edu), University of Colorado
Avi Mandell, Pennsylvania State University

Terrestrial planets are thought to form in a bottom-up accretion scenario, from km-sized "planetesimals" and Moon-sized "planetary embryos". During this process, water is accreted by the inner planets by impacts from bodies originating in distant, colder regions of the disk. Giant planets are constrained to form in the few Myr lifetimes of gaseous disks; more quickly than terrestrial planets. Thus, the final stages of terrestrial accretion are strongly affected by any giant planets that are present. Since giant planets are easier to detect, we can use the distribution of known giant planets to infer the unknown properties of terrestrial planets. We establish limits on the giant planet orbits that permit the formation of a terrestrial planet in the habitable zone of its parent star. These limits apply to systems like our own with giant planets outside the terrestrial planet zone, and also to systems with close-in giant planets. Dynamical simulations show that Earth-sized terrestrial planets can form after giant planet migration, often with orbits in the habitable zone. Such planets accrete a very large amount of water and are likely to be covered in global oceans. More than a third of the known systems of giant planets could have formed a terrestrial planet in the habitable zone. Thanks to the Virtual Planetary Laboratory, a NASA Astrobiology center, for funding.